

Characterization of Covetic Materials for Process Control

Final CRADA Report

Applied Materials Division

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prepared by
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Non Proprietary Final CRADA Report

For the Office of Scientific and Technical Information (OSTI)

CRADA Number: ANL/AMD-C2017-17115

CRADA Title: Characterization of Covetic Materials for Process Control

CRADA Start Date 8/7/2017 – **End Date** 8/7/2018

DOE Program or Other Government Support

Program office: DOE – EERE Advanced Manufacturing Office

Program manager name: Dr. David Forrest

Program manager phone or email: 202-586-5725

Participant(s)

Participant 1 name: GDC Industries, LLC

Complete address: 49 Front Street, Dayton, OH 45402

Participant 2 name: Click or tap here to enter text.

Complete address: Click or tap here to enter text.

Participant 3 name: Click or tap here to enter text.

Complete address: Click or tap here to enter text.

Argonne National Laboratory

Argonne PI(s): U. (Balu) Balachandran

Funding Table

To add rows, right-click in bottom row and select "Insert" "rows above".

	Planned Funding	Actual Funding	In-Kind
Government	\$ 300,000.00	\$ 300,000	
GDC Industries, LLC	\$	\$	\$ 116,114.00
Enter Participant 2 here	\$	\$	\$
Enter Participant 3 here	\$	\$	\$
Total	\$ 300,000.00	\$ 300,000.00	\$ 116,114.00

Nature of Work

Describe the research (summary of Scope of Work and principal objectives of the CRADA):

GDC Industries LLC has been performing process research on covetic materials since its formation in February 2015. With assistance from DOE and the Air Force via SBIR projects, GDC focused on the enhancement of aluminum alloys to covetics to replicate a previously reported electrical conductivity of about 67% IACS (International Annealed Copper Standard). GDC has established a joint development agreement with General Cable Corporation, wherein General Cable agreed to perform numerous extrusions of as cast covetics and subsequent tensile and electrical conductivity tests on the resultant wire. Covetics conversion was proven but the significant improvement is yet to be replicated. To control the experiments towards enhanced process control, a series of designed experiments was created by an expert in process control from the automotive industry. Six process variables were identified and a designed experiment matrix requiring 18 independent conversions was created at GDC. The result of those designed

experiments has now allowed GDC to focus on two process variables, namely, residence time and DC current in the conversions with the other four variable held constant. While this work is useful in replicating the earlier enhancements, GDC feels it will not be sufficient for the necessary process know-how for scale up required by industry as GDC still does not have a direct correlation of the process variables to the actual carbon in the finished covetics. Since 2015, GDC has been aware of the capabilities existing at Argonne National Laboratory for performing carbon analysis that exceeds the precision commonly available to Industry. GDC and ANL submitted a proposal in response to the DOE-EERE – Small Business Vouchers Pilot Program announcement and the proposal was selected for funding. GDC will melt-process covetic aluminum samples following their design of experiment criteria and have the as-casted samples extruded by their partner, General Cable. Argonne will measure the conductivity, analyze carbon content, perform X-ray diffraction, and examine the microstructural features of the samples. Careful process variable measurements will be recorded by each party such that correlations can be developed indicating process parameters that yield the best carbon concentration in covetics.

DOE mission area(s):

Energy and Environmental Science and Technology

Materials Science

Materials Science

Conclusions drawn from this CRADA; include any major accomplishments:

Over 25 samples were analyzed for carbon content by LECO and SEM/EDS techniques. The targeted carbon content in those samples varied from 0% to 12 wt.%. LECO detected <1% carbon in these samples (highest carbon detected by LECO is 0.8 wt.%. Highest carbon detected was 8 wt.% by SEM/EDS. There is always background carbon in SEM/EDS chambers and this background carbon level varies at different times for the same chamber. The measured electrical conductivities of the as-extruded samples were in the range 53 - 55% IACS. Upon annealing at 570C for 2 hr decreased (as expected) to ~50% IACS. No significant enhancement in carbon level and electrical conductivity is observed by GDC's covetic conversion process. XRD analysis showed presence of aluminum carbide phase in several of the samples fabricated by GDC. Major conclusion from our study is that not much carbon is incorporated in the GDC samples processed as per their design of experiments. It is possible that majority of added carbon is lost during their process conditions. Formation of aluminum carbide can account for the lower electrical conductivity in these samples.

Technology Transfer-Intellectual Property

Argonne National Laboratory background IP:

None. ANL's role in this CRADA is to characterize the samples fabricated by GDC Industries, LLC.

Participant(s) background IP:

None made available to ANL

Identify any new Subject Inventions as a result of this CRADA:

None

Summary of technology transfer benefits to industry and, if applicable, path forward/anticipated next steps towards commercialization:

Based on our characterization work we did not see covetically converted carbon in their samples processed by following design of experiments study. We saw no improvement in conductivity and observed evidence for aluminum carbide formation. This CRADA work was useful to GDC Industries in realizing that they have to modify their melt-processing conditions to minimize/eliminate carbon loss and prevent aluminum carbide formation. It is

believed that GDC Industries will respond to SBIR solicitations with proposals to make better ceramic samples with enhanced properties.

Other information/results (papers, inventions, software, etc.):

None resulted from this work.

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